

## Appendix H – Mariposa Port of Entry Simulation

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## **1 Introduction**

The main purpose of the simulation analysis of the Mariposa Port of Entry (POE) is to determine the impact that the operation of a container terminal would have on the operations of the port. Some of the measures of performance selected to assess this impact include: increased average time in the queue and additional inspection operation.

The estimation of the impact on the POE is performed through the present simulation model. The model is based on the ProModel® V6.0 Montecarlo simulation package and its aimed to obtain a valid, logical representation of the performance of the port for its current situation, particularly at the high season (from November through May). Then, on a second stage, we analyzed the impact of the operation of a container terminal in the Port of Guaymas. Some of the elements built into the model include: current and predicted levels of infrastructure, scheduled arrivals of trucks, and internal operations of inspections, such as X-Ray and super-booths. The characteristics built into the model are in accordance with the current operation of the Mariposa POE as reviewed by their personnel.

Finally, the simulation was built to estimate the current capacity available at the POE to handle trucks, the average waiting time of the trucks at the border, and the hours of operation required at the POE to process all the cargo on a given day. Simulation modeling allows the generation of several scenarios with different levels of operation of for the container terminal at the Port of Guaymas, in order to evaluate different potential outcomes.

## **2 Process Flow**

In the current model the trucks are represented as entities that will be processed in the POE in a first come first served order. The trucks can have different attributes that differentiate them for the purpose of the activities to be performed at the POE. For example there are some trucks that come empty and are only subject to Pre-Screening and Primary inspections, and a motor vehicle safety inspection if required; but a fresh produce truck can have more inspections than these three. Based on historical data, percentages of the types of trucks crossing in any given day and the types of inspections they are subject to in a normal operation were obtained. This was used as an input to the model so the daily mix of vehicles-inspections could be estimated for the peak season.

The logic flow of entities in the simulation is explained in the diagram in Figure 1, but for more detailed information about the Mariposa POE Process the reader should review Appendix H. The logical process in the POE is as follows: when a truck enters the inspection process it can be released automatically or requested to go through different inspection stations before being authorized to cross from the port to the United States.

The whole system can be divided into four different sections:

1. Pre-Screening and Primary Inspection: These are the first two steps in the process and all trucks go through them.
2. Secondary Inspection: Different tasks can be done in this section: normal secondary inspection, 100% inspection (unloading all the cargo), weapons and enforcement inspection, and others.
3. X-Ray: There are three stations for X-Ray inspection.
4. ADOT Compound: ADOT's Motor Vehicle Division safety inspection and other Federal inspections are conducted here.

## Mariposa POE Simulation Process Map

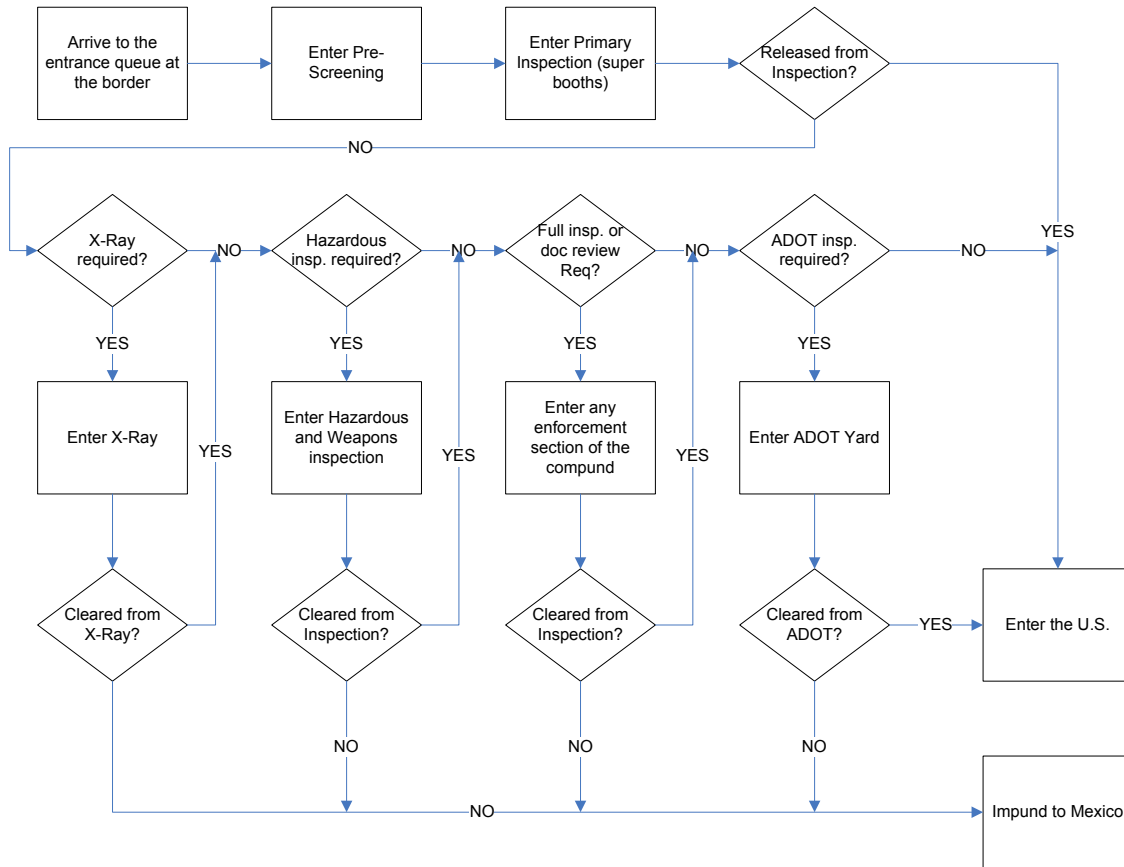


Figure 1 - Mariposa POE Simulation Process Map

While the trucks move through all the different individually required steps of the inspection process, several institutions work together. A partial list includes:

- Customs and Border Protection (CBP)
- United States Department of Agriculture (USDA)
- Food and Drug Administration (FDA)
- Arizona Department of Transportation (ADOT)
- Federal Motor Carrier and Safety Administration (FMCSA)

The physical movement of the trucks is simple and can be observed in the animation of the simulation (Figure 2 shows an image of the simulation interface). Currently trucks cross the border in two lanes, enter one of the two pre-screening stations, follow to one of the four primary inspection super-booths, and then proceed to Nogales, Arizona (AZ) or for further inspection

always driving in a Counter Clock Wise (CCW) motion around the compound. These rules are adjusted as the team at Mariposa attempts to be more efficient and to react to demand changes.

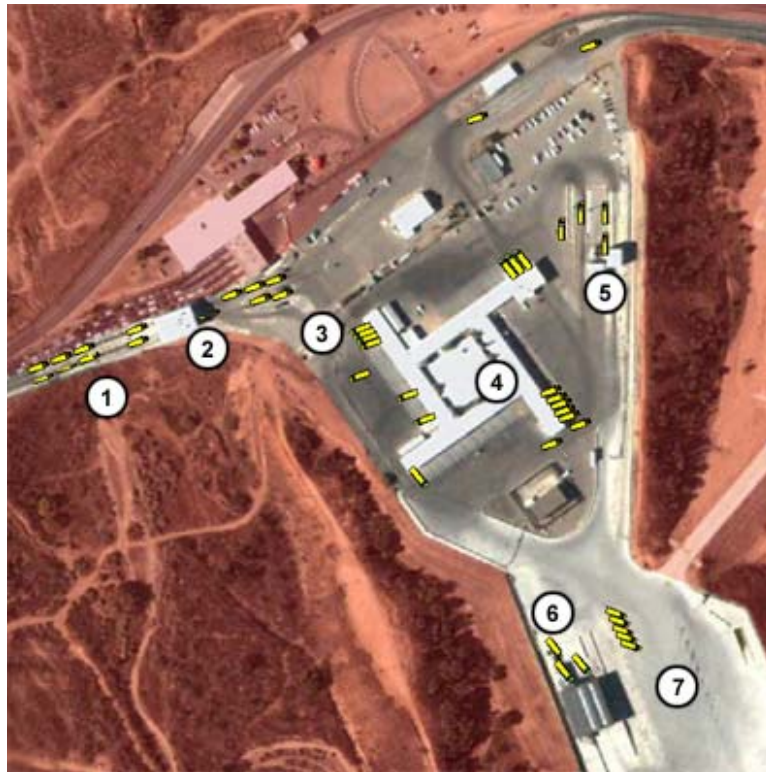


Figure 2 - Graphical Interface of the Simulation Program for the Mariposa POE

### 3 Assumptions of the System

Given the security requirements at the site of the POE, we were not able to observe and record all the activities that we would have liked, however we interviewed extensively the port's personnel to obtain an overall idea of the operations performed, as well as real data about the inspection process followed there.

Because of these limitations and the modeling restrictions present in any abstraction of a system, such as the simulation model of the POE, we defined some assumptions about the operation of the system that we describe next:

#### 1.1 Infrastructure

The physical infrastructure of the POE is presented in Figure 2. Each facility is described next, with the help of a numbering system that matches the numbers in the figure:

1. There are two lanes (queues) before crossing the physical border, which are exclusively used by cargo trucks (Figure 2).
2. There are two pre-screening lanes and inspection stations (PSA).
3. There are four primary inspection stations (super-booths).
4. There are different quantities of docks in each side of the main compound, where the grading and detailed inspection takes place.
5. There are three X-Ray stations.
6. There are two inspection lanes in the ADOT yard.
7. There are 26 parking spaces at the ADOT yard.

The detailed description of the infrastructure in the main compound is presented by Table 1. We last updated this table in December 2005, and changes can always occur, but as far as we know this is the latest version.

Table 1 - Equipment available at the main compound

Side	Available Docks
North	18
South	20
West	15
East	21

## 1.2 Movement Logic

Trucks move inside the compound in a counter clock wise (CCW) motion and follow the next priorities when several inspections are required:

1. X-Ray
2. Enforcement (full inspection, hazardous and weapons inspection, etc)
3. Document Review
4. ADOT (all inspections done at the ADOT yard)

Due to physical limitations trucks that are released in the fourth (last to the east) super-booth must go into the compound and drive around to take the road again.

Trucks that require an X-Ray inspection will go into the ADOT yard and form a line from there towards the X-Ray booths.

## 1.3 Processing Details

A normal daily demand of 1,300 trucks was assumed based on the highest rates seen in the 2005-2006 peak season and on CBP's advice. The percentages of trucks that fall within each type of inspection are presented in Table 2, according with information obtained from CBP and ADOT personnel at the Mariposa POE.

Table 2 - Historical distributions of inspection procedures

Percentage	Description
100 %	Pre-Screening
100 %	Primary Inspection
50 %	Released to enter the US from Primary inspection
50 %	Required further inspections and enter the compound
	Out of the 50 % that requires more inspection:
33 %	Required X-Ray
17 %	Required Full Inspection or Hazardous and Weapons Inspection
83 %	Required Documentation Review
20 %	Required to enter the ADOT yard for Inspection

The inspection times required in each station were estimated according with the historical data provided by the different entities we interviewed, the summary of these results are presented on Table 3, according with this information the pre-screening process follows the Erlang distribution with an average processing time of 0.72 minutes (with a shape parameter of 3). In contrast the

inspection at the ADOT compound follows a triangular distribution with a mode (the most likely time) of 30 minutes per truck, a minimum of 25 minutes and a maximum of 45 minutes.

Table 3 - Distribution of processing time of each activity at the POE

Inspection	Time Distribution (min)
Pre-Screening	ERLANG (0.72, 3)
Primary Inspection	ERLANG (1.33, 3)
* 20% including ADOT in Super-Booth	ERLANG (2, 3)
Document Revision	ERLANG (20, 3)
Full Inspection	ERLANG (80, 3)
Hazardous and weapons Enforcement	ERLANG (80, 3)
X-Ray	ERLANG (4, 3)
ADOT	TRIANGULAR (25, 30, 45)

We also assumed that trucks don't start arriving to the border until 9:00 AM every day. This is caused by the fact of most companies start operating at 8am and Mexican Customs also starts operations at 8 AM.

#### 1.4 Arrivals

There are two streams of arrivals to the system; the first is the current demand from cargo trucks coming to the border and the second one are the trucks coming from Guaymas once the container terminal is in operation. For the first stream we assume that there will not be any change and it will stay at the current observed levels of 1,300 trucks per day (as seen at the most critical time of year).

For the second stream, we assume that it is dependent on the level of activity at the container terminal in Guaymas, as shown in **Error! Reference source not found.**, the information obtained from the Port of Guaymas simulation model is used as input in the Mariposa POE simulation model to obtain the desired results. A brief description of the process map and the simulation model developed follow.

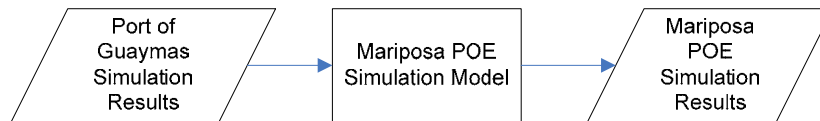


Figure 3 - Mariposa POE Simulation Input



## 1.5 Simulation Scenarios

In order to determine the impact on the Mariposa POE of a container terminal in the Port of Guaymas different scenarios were ran using simulation models. After defining the different scenarios to be analyzed and obtaining results from the Port of Guaymas simulation, the resulting information was used to make an assessment of the Mariposa POE capacity, and the impact of the containerized cargo moving by highway on the POE. The information used for each scenario is shown in **Error! Reference source not found.**4. The first column gives the scenario number (in accordance with the scenarios ran in the Port of Guaymas simulation). The second column shows the TEU (Twenty-foot equivalent units) per week expected to pass through Guaymas. On the third column the number of actual containers to be moved weekly by the Port of Guaymas is presented. In the fourth and fifth column the distribution percentage assumed for containers being moved by truck and by rail is shown. The sixth column shows a current daily demand – assumed for a peak season normal day of operations- to analyze the different scenarios; this number was fixed based on historic data, interviews with Mariposa’s personnel and current demand in the port of entry. The extra demand expected daily from the Guaymas’ port operation is shown in the seventh column and the total number of containers to cross the Mariposa POE is shown in the last column.

Table 4 - Information Used for Each Scenario for the Mariposa POE

Cases	TEU	Containers	Truck %	Rail %	Current Demand	Qty Exit Port	Extra Demand	Rate (min)	Total Demand
Current	--	--	--	--	1300	0	0	0	1300
1	400	230	0	100	--	--	--	--	-
2	400	230	100	0	1300	230	154	3.9	1454
3	400	230	50	50	1300	108	76	7.93	1376
4	400	230	30	70	1300	72	42	14.5	1342
5	400	230	70	30	1300	50	50	5.5	1350
6	1200	690	0	100	--	--	--	--	-
7	1200	690	100	0	1300	233	154	3.9	1454
8	1200	690	50	50	1300	128	73	8.3	1373
9	1200	690	30	70	1300	74	38	16.07	1338
10	1200	690	70	30	1300	164	110	5.49	1410
11	400	230	0	100	--	--	--	--	-
12	400	230	100	0	1300	239	239	1.99	1539
13	400	230	50	50	1300	113	113	3.55	1413
14	400	230	70	30	1300	157	157	2.8	1457
15	400	230	30	70	1300	76	76	6.47	1376
16	1200	690	0	100	--	--	--	--	-
17	1200	690	100	0	1300	233	233	1.97	1533
18	1200	690	50	50	1300	112	112	3.57	1412

19	1200	690	70	30	1300	169	169	2.8	1469
20	1200	690	30	70	1300	68	68	5.85	1368
21	2000	1150	50	50	1300	105	77	7.83	1377
22	2000	1150	50	50	1300	112	112	3.82	1412
Max	--	--	--	--	2000	0	0	0	2000

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#### 4 Results & Statistical Evaluation

The results of running the simulation of the POE under the previews described scenarios are shown in **Error! Reference source not found.** Once more, the first four columns show the scenario conditions. The fifth column shows the expected average time in the system of each truck moving through Mariposa. In the sixth column, the total amount of minutes required to process the demand of any given day is shown. The extra hours required (against the current working time) to clear the compound with the increased activity is shown in the seventh column. The eighth column is the highest observation of trucks in queue to enter the compound. Finally, the ninth and tenth columns show the bottleneck of the system and its utilization per the simulation study.

Table 5 - Results of Running the Simulation of the POE

Cases	TEU	Truck (%)	Total Demand (truck)	Truck Time in System	Operation Time (minutes)	Extra Hours	Max in Queue (trucks)	Bottleneck	Aprox Utilization
Current	-	-	1300	45.22	764.22	1.74	163	Pre-screening	75.69%
1	400	0	-	-	-	-	-	-	-
2	400	100	1454	75.34	830.82	2.85	278	Pre-screening	75.64%
3	400	50	1376	57.97	830.45	2.84	265	Pre-screening	73.27%
4	400	30	1342	50.01	820.36	2.67	217	Pre-screening	72.49%
5	400	70	1350	61.10	808.24	2.47	202	Pre-screening	74.69%
6	1200	0	-	-	-	-	-	-	-
7	1200	100	1454	75.34	830.82	2.85	278	Pre-screening	75.64%
8	1200	50	1373	63.54	838.70	2.98	238	Pre-screening	72.93%
9	1200	30	1338	57.46	840.94	3.02	202	Pre-screening	70.70%
10	1200	70	1410	68.64	851.05	3.18	259	Pre-screening	73.83%
11	400	0	-	-	-	-	-	-	-
12	400	100	1539	101.41	897.18	3.95	401	Pre-screening	76.65%
13	400	50	1413	76.94	856.84	3.28	294	Pre-screening	73.49%
14	400	70	1457	80.91	835.51	2.93	280	Pre-screening	78.05%
15	400	30	1376	58.21	844.87	3.08	191	Pre-screening	72.61%
16	1200	0	-	-	-	-	-	-	-
17	1200	100	1533	96.14	881.52	3.69	355	Pre-screening	76.98%
18	1200	50	1412	72.13	854.13	3.24	271	Pre-screening	73.75%
19	1200	70	1469	84.80	874.52	3.58	309	Pre-screening	74.65%
20	1200	30	1368	62.83	831.53	2.86	200	Pre-screening	73.88%
21	2000	50	1377	58.44	841.42	3.02	203	Pre-screening	73.06%
22	2000	50	1412	75.06	839.80	3.00	246	Pre-screening	76.26%
Max	-	-	2000	197.91	1,139.78	8.00	835	Pre-screening	78.41%

Some of the results that can be obtained from the simulation include the following:

- The expected average time for each truck to go through the port of entry will increase from a current  $45.67 \pm 6.03$  minutes delay to a  $101.86 \pm 9.63$  minutes expected worst case scenario delay –when 239 (in average) containers leave the port of Guaymas in a single day at a rate enough to reach the border the same day (see Table 6).
- Under the Max scenario the waiting time increased to  $198.36 \pm 9.50$  (see Table 6). As it was advised by the personnel at Mariposa, demand over 1'500 trucks/day would be considered over capacity and have an impact in the waiting times.

Table 6 - Confidence Intervals of truck's Time in System

Truck Time in System							
Scenario	Mean	Low 95%	High 95%	Scenario	Mean	Low 95%	High 95%
Current	45.67	39.64	51.70	S13	77.39	70.39	84.38
S2	75.79	68.02	83.57	S14	81.36	73.59	89.12
S3	58.42	49.08	67.77	S15	58.66	54.25	63.07
S4	50.46	43.71	57.21	S17	96.59	88.81	104.38
S5	61.55	52.54	70.57	S18	72.58	61.58	83.57
S7	75.79	68.02	83.57	S19	85.25	77.94	92.55
S8	63.99	57.11	70.87	S20	63.28	53.63	72.93
S9	57.91	50.25	65.58	S21	58.89	52.77	65.01
S10	69.09	58.98	79.20	S22	75.51	70.25	80.77
S12	101.86	92.23	111.49	Max	198.36	188.86	207.87

Note: Scenarios 1, 6 & 11 are not moved by Truck.

- Even though the waiting times could seem to be different, when analyzing the 95% confidence intervals we found that there is not a statistical difference between most of the scenarios –although there is a tendency to increase in scenarios that assumed the usage of quay cranes in Guaymas and more than 70% of containers traveling by trucks (see Figure 4). The maximum scenario ran did show a great difference in waiting times against the rest.

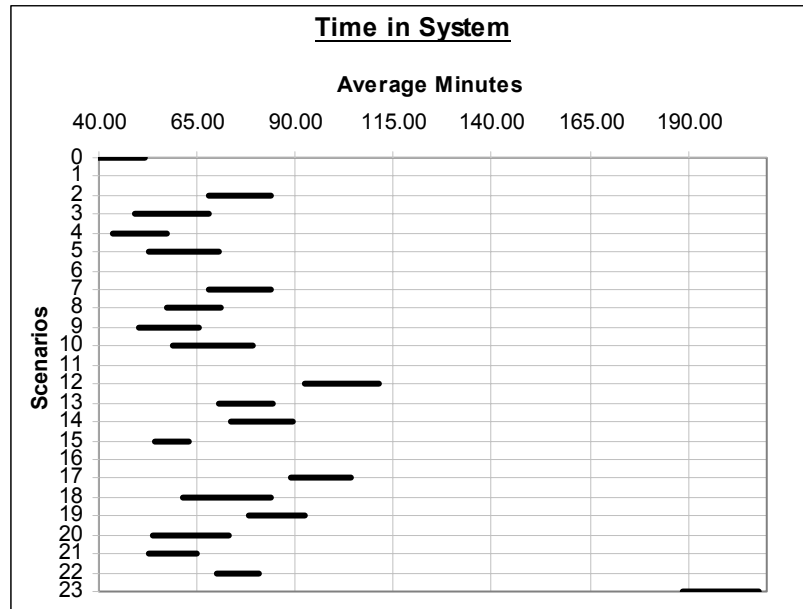


Figure 4 - Confidence Intervals of truck's Time in System chart

- When comparing the statistical difference between the three different types of scenarios in terms of the number of TEU being processed at the port of Guaymas we found no difference between the minutes each truck must wait for inspection at the POE in each of them (see Figure 5)

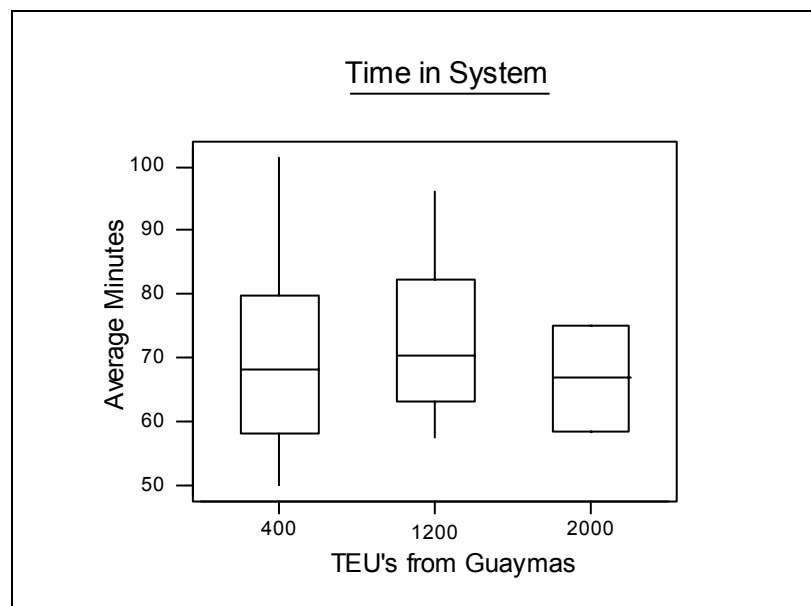


Figure 5 - Confidence Intervals of truck's Time in System boxplot

- The processing of the additional demand could require up to 2.2 additional hours of operation of the POE personnel (see Table 7). Based on current information from Mariposa, we know that to process a daily demand of 1'300 trucks an additional 1.5 hours should be worked over regular schedule –to finish around 8:30 pm. With the simulation results we can estimate that under current operation conditions it could be required for the POE to work almost 4 extra hours (11 pm) to clear the demand in a worst case scenario –when 239 (in average) containers leave the port of Guaymas in a single day at a rate enough to reach the border the same day (see Table 7).

Table 7 - Confidence Intervals of Mariposa's daily operation hours

Daily Operation Time							
Scenario	Mean	Low 95%	High 95%	Scenario	Mean	Low 95%	High 95%
Current	764.22	736.36	792.08	S13	856.84	822.55	891.14
S2	830.82	861.19	891.56	S14	835.51	813.28	857.73
S3	830.45	794.32	866.58	S15	844.87	810.38	879.37
S4	820.36	796.83	843.88	S17	881.52	856.29	906.74
S5	808.24	769.51	846.96	S18	854.13	828.2	880.07
S7	830.82	861.19	891.56	S19	874.52	843.51	905.53
S8	838.7	808.33	869.07	S20	831.53	802.82	860.24
S9	840.94	824.24	857.64	S21	841.42	809.2	873.64
S10	851.05	816.45	885.65	S22	839.8	790.69	888.91
S12	897.18	861.86	932.51	Max	1139.78	1095.5	1184.06

Note: Scenarios 1, 6 & 11 are not moved by Truck.

- There is no statistical difference between most of the scenarios except for the current model and the max (see Figure 6). The same tendency to increase for the worst case scenario is seen (as in the previews bullet)

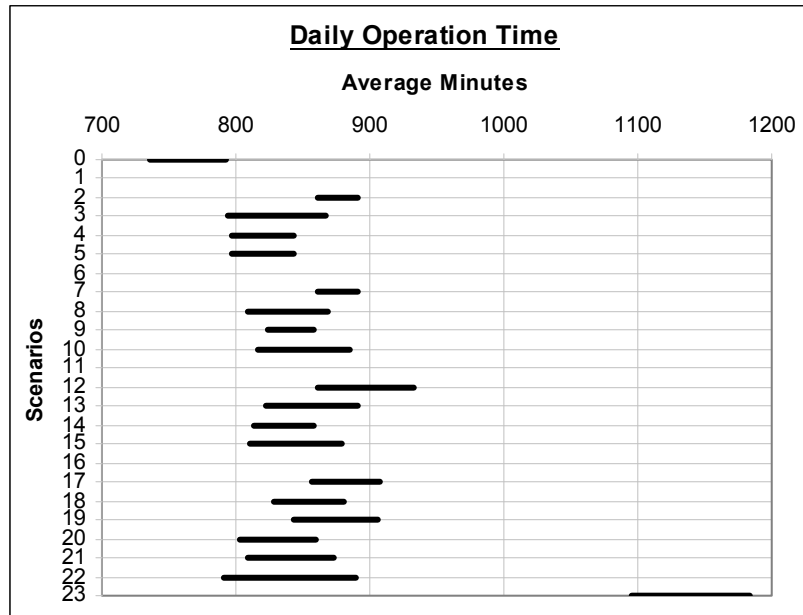


Figure 6 - Confidence Intervals of Mariposa's daily operation time chart

- When comparing the statistical difference between the three different types of scenarios in terms of the number of TEU being processed at the port of Guaymas we found no difference in the extra hours required at the POE to process each of them (see Figure 7)

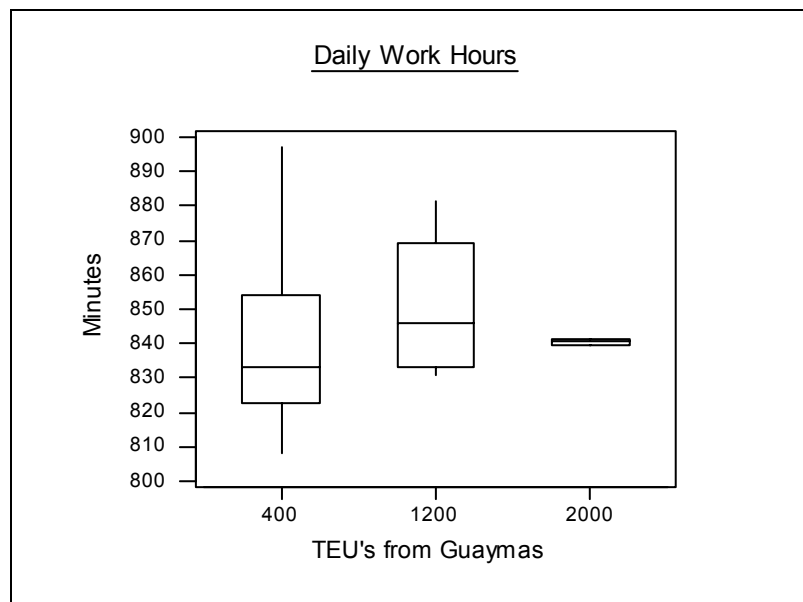


Figure 7 - Confidence Intervals of Mariposa's daily operation time boxplot

## 5 Validation

For the purpose of validating our results we followed two different approaches, the first was subjective, because it involved the expert witness of the supervisors of the current operation of the POE, and the second one was quantitative, consisting in the time required to process all the trucks in a given day, which is as information that is readily available to us.

After the first version of the simulation for the POE was finished we invited the supervisors in charge of operations to review the simulation and the assumptions included in the model. From this review the personnel from the port agreed on the general validity of the assumptions and we made some minor adjustments to the model.

The second procedure consisted in measuring in a quantitative way that the behavior of the real system is similar to that of the simulation. For this purpose we collected several days' worth of data with the total amount of trucks processed per day and the closing time of the POE. The closing time is when all the trucks have been processed there are none waiting or in the compound. There are two assumptions that we made regarding this issue: the first is that trucks start arriving to the POE at 9:00 AM because Mexican customs opens at 8:00 AM; second, the last truck of any given day will enter the systems around 6:00 PM since it is the closing time at Mexican customs.

The time it takes for the POE to close is dependent on the amount of trucks still pending to process, which is at the same time dependant on the processing time and the product mix of all the trucks during the day. For this reason we argue that this measure should give as an adequate validation of the behavior of the system throughout the day.

When comparing the current scenario with the information obtained from CBP's personnel, we found that the total processing time was in average of 12.74 hours –which gives a closing time of 8:44pm (see Table 8).

Table 8 - Current scenario total operation hours

Replication	Total Minutes	Total Hours	Extra Hours	Closing Time
1	733.34	12.22	1.22	8:13 PM
2	820.99	13.68	2.68	9:41 PM
3	798.55	13.31	2.31	9:19 PM



4	721.34	12.02	1.02	8:01 PM
5	710.69	11.84	0.84	7:51 PM
6	737.96	12.30	1.30	8:18 PM
7	753.24	12.55	1.55	8:33 PM
8	791.13	13.19	2.19	9:11 PM
9	765.43	12.76	1.76	8:45 PM
10	809.54	13.49	2.49	9:30 PM
Average	764.22	12.74	1.74	8:44 PM

## **6 Conclusion**

The validation of the assumptions in our model, gives us confidence in the validity of the results from this simulation. The statistical evaluation of the results allows us to have confidence on the significance of the results, that is, that the equalities perceived are not generated by the randomness in the system, but that the factors tested really make an impact in the performance measures of the system, such as truck time in system and POE daily operation time. With these evaluations we can be certain that the recommendations we provide based on the simulation are based on an adequate abstraction of the model.

Finally we recommend that this model should not be used to determine other results, other than the rough capacity and performance estimation of the system in the conditions tested. The process followed by the POE changes continually as personnel of the compound adjusts to be more efficient; also some infrastructure improvements are already approved and will change the basic assumptions of this model.